THE PLANETARY REPORT

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FASCINATING MARS

VISIONARIES WHO INSPIRED A PASSION FOR EXPLORATION

HUNDRED-YEAR SPACE PLAN ✻ NASA BUDGET ✻ PLANET HUNTING WITH SMALLER TELESCOPES

EMILY STEWART LAKDAWALLA
blogs at planetary.org/blog.

Crashing into the Moon

Japan's *Hiten* Gave Us a Unique View

***HITEN* LAUNCHED ON JANUARY 24, 1990,** as Japan's first technology demonstration mission to the Moon. It had only one scientific instrument, a dust counter, which operated for as long as the mission functioned, but it also carried an optical navigation camera designed to take small photos rapidly from the spinning spacecraft. While *Hiten* was in orbit, these images were useful only for navigation, but when the craft was intentionally crashed into the Moon on April 10, 1993, its little camera took photos all the way down to its impact between the craters Stevenius and Furnerius. The resulting image sequence was reminiscent of that taken in 1965 by *Ranger IX* before it plunged onto the lunar surface. The white dot at lower right marks *Hiten*'s impact point.

–Emily Stewart Lakdawalla

LEARN MORE ABOUT THIS IMAGE PLANETARY.ORG/SNAPSHOTS

SEE AN ANIMATION OF THE DESCENT BIT.LY/TPS120402

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Hiten/ONS data courtesy JAXA. Processed version copyright Ted Stryk; NASA/JPL/USGS

ON THE COVER: A century after Percival Lowell created his iconic drawings of Mars—records of his telescopic observations from atop an Arizona mountain—we know the place better than any other world in the solar system, save for Earth. Many of today's Mars explorers were inspired by the pioneering work of early astronomers like Lowell and science fiction writers like Edgar Rice Burroughs. The evolution of humankind's view of the Red Planet is reflected in this 1908 Lowell map overlaid on a global mosaic from *Viking 1*. *Images: Lowell Observatory Archives and NASA/JPL*

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BILL NYE *is chief executive officer of The Planetary Society.*

Three Ways We Work

Involving You in Planetary Exploration

ALTHOUGH IT'S A GREAT BIG UNIVERSE, I often think of our Society as being good, or even great, at three things: we create, educate, and advocate. These last few months, we have been doing all three in earnest.

WE CREATE

The *LightSail™* and its twin backup spacecraft have been built. It's now a matter of time; we await a ride, a ride on a rocket to medium Earth orbit. Along with its remarkable performance capabilities, more advanced than in any light-pressure-driven craft yet conceived, *LightSail* is super-shiny. I mean extraordinarily shiny—very reflective. If all goes well, we will all be able to see it with the unaided eye from Earth's surface. Shortly after launch, The Planetary Society will work to get everyone on Earth to pause to watch this remarkable little craft sail by, high overhead.

DOING MORE WITH LESS

LightSail's flight will be inspirational, as it symbolizes something that I feel is vital to our future: being more efficient by doing more with less. Keep in mind also that both *LightSail* spacecraft were built by you—enthusiastic and committed members of The Planetary Society who want to be part of our future in space. That alone is novel, getting people all over the world to give a modest amount for the greater good of advancing humankind's ability to explore. Solar sailing has the potential to drastically lower mission costs to the destinations in our solar system because, once lofted, the spacecraft need no fuel. Someday soon, we may have solar sail spacecraft in an orbit much closer to the Sun than Earth's. They would carry instruments to monitor the Sun's electromagnetic weather, which affects our communication systems here on Earth. You will have helped to advance that technology.

CLEAN, GREEN FUTURE

As a side note to the eco-friendly spirit of *LightSail*, in the not-too-distant future, it is quite likely that citizens who live near rocket launch facilities will grow ever more concerned about the environmental effects (impacts) of rocket launches. They will not want noxious exhaust gases wafting toward their neighborhoods, and they won't want the often toxic and caustic fuels transported through their towns. In an optimistic scenario, we will be producing rocket fuels from genetically modified algae. These organisms will produce, instead of lighter-than-air swamp gas, higher-molecular-weight fuel oil that is well suited to our current kerosene/oxidizer rocket engines.

Carrying the solar idea one step further, sunlight will enable the production of electricity, which will power special grow lights tuned to the algae's favorite frequency. The solar cells for this electricity will be directly derived from spacecraft technology. The plants will take carbon dioxide out of the atmosphere and return it during combustion. The renewably produced electricity will in turn be used to run cryogenic refrigeration systems to produce liquid oxygen. After being launched to orbit by this environmentally responsible fuel system, spacecraft will rely on propulsion by sunlight. Not bad. It's in the future, but perhaps not so distant.

WE EDUCATE

I was invited once again to be a guest of the White House Science Fair. There were 40 projects created by students from around the United States. They were of an age such that they used to watch me on my *Bill Nye the Science Guy*® show. This year marks the 20th anniversary of that series. I was deeply gratified by the many accomplished young people who told me that the series inspired

Associated Press/Susan Walsh

LEFT *President Barack Obama shakes hands with Bill Nye at the second White House Science Fair, held February 7, 2012. Obama hosted this event to celebrate student winners of a broad range of science, technology, engineering, and math competitions from across the United States.*

them. As you may have inferred over these last few issues of *The Planetary Report*, I feel it is our job at the Society to educate young people as well as to interest and enlighten adults. Several people said they had seen and appreciated the new Planetary Society Kids section. The president of the United States shook my hand and encouraged me to keep up the good work. It was quite a moment for me. In the middle of this magazine, please find this issue's Planetary Society Kids pages; we cover an astrobiological application of algebra. I strongly feel that this is very much in keeping with our founders' vision, Carl Sagan's in particular. Learning about mathematical relationships in nature and observing the processes of life are essential to our species' future. I'm proud to be part of it. I hope you are as well.

SEDS AND THE SOCIETY

Five young people from the Students for the Exploration and Development of Space (SEDS) visited the Planetary Society offices in Pasadena. Along with the fun we had talking about rockets, we reached some substantive agreements regarding memberships, career counseling, and engaging young people in the important processes of space policy and political advocacy. Two of them–Erik Lopez and Michael Zwach–joined me onstage at the National Science Teachers Convention in Indianapolis. They described how space exploration had inspired them to pursue careers in engineering. With students like these in the pipeline, the future of space exploration is bright.

WE ADVOCATE

Unfortunately, while holding this optimistic view of spaceflight in the long term, we will soon be in the thick of a political advocacy battle about the short term. Although we are an international organization, NASA remains the world's largest space agency, spending a bit more than four and one half times that of the Russian Federal Space Agency and more than thrice that of the European Space Agency. So, what happens at NASA concerns everyone involved in space exploration. With the worldwide economic crisis, government budgets are, quite reasonably, being cut. NASA's is no exception. Our problem as planetary space explorers is that the line items associated with NASA's Science Directorate, and especially planetary exploration, have been cut to the point that the agency will not be able to mount another so-called flagship mission. That's a general term referring to

THIS IS YOUR ORGANIZATION, AND I WANT TO HEAR FROM YOU.

E-mail me at *tellbill@planetary.org* or send a letter to Bill Nye at

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Find more information at *planetary.org/yourplace*

ABOVE *Test operators monitor how NASA's Mars rover* Curiosity *handles driving over a ramp during a test on September 10, 2010. If we continue down the funding path that the U.S. government is proposing,* Curiosity *may be the last of humankind's flagship missions.*

missions that cost more than $1.5 billion and take about 10 years to plan, launch, and return images and data. Unless we turn things around, the *Mars Science Laboratory (MSL)* mission with the rover *Curiosity* will be the last such mission. This is bad for all of us, all of humankind.

In the general sense, these cutbacks were not a surprise. In fact, the U.S. National Research Council (NRC) Decadal Survey, which is a plan for space exploration, includes contingency schemes for reduced budgets. What took us all aback were the deep cuts to planetary exploration. We will seek your help in rebalancing the budget of the world's largest space agency.

The idea, the consensus, of the thousands of scientists consulted in developing the Decadal Survey is to maintain a program of steady exploration. We don't want to lose our expertise; if projects are run on an on-again, off-again basis, the rocket scientists, engineers, and astrobiologists who can plan and execute these complex missions will drift away and seek employment elsewhere. The program for deep-space exploration is not a faucet you can turn on and off. Once it's gone, we may never get it back—or at least not for decades.

THE VERGE

We have to remind U.S. lawmakers and decision makers that we are, as a species, as nearly as we can tell, on the verge of finding evidence of life on another world. The first logical site to look is someplace where it's wet on Mars. Beyond this, we hope to send life-searching missions to Europa and Enceladus. I cannot overstate the effect of such a discovery. It would be profound, utterly life-changing. We would never again wonder whether or not we're alone. We would not be.

Among my responsibilities to you as CEO of The Planetary Society is making certain that our support for a steady, well-planned search continues. I find the idea of life elsewhere so compelling that I often wonder if our leaders have taken those few moments to really consider what it would mean to humankind. We will remind them.

Finding life off Earth would be a legacy like no other in human history. And the discoveries involved will have been made by people from around the planet—people like you. Space exploration brings out the best in us. Thanks for your support. With your help, we can change the world a little bit.

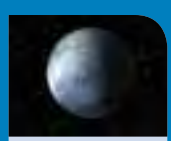
If you've missed *Planetary Radio* lately, here are some recent highlights:

Rex Walheim on recruiting the next generation of young astronauts

A planet's habitability with astrobiologist Dirk Schulze-Makuch

The controversial James Webb Space Telescope

Emily Lakdawalla with the president of the Space Tourism Association



Alan Stern and the Pluto postage stamp

Astronomers at La Sagra with a new near-Earth object (NEO)

Illustrator Michael Carroll's new book, *Drifting on Alien Winds*

Jill Tarter continues the SETI search

Find these shows and our entire archive of *Planetary Radio* at *planetary.org/radio*!

Photo: Tunç Tezel

LEFT *Alpha and Beta Centauri, two parts of the three-star system nearest our Sun, glow just right of center in this Milky Way–frosted sky over Mangaia island. Our resolve to sail to distant stars is a fitting answer to poet Robert Browning's question, "Ah, but a man's reach should exceed his grasp,/ Or what's a heaven for?"*

Stepping Lightly to the Stars

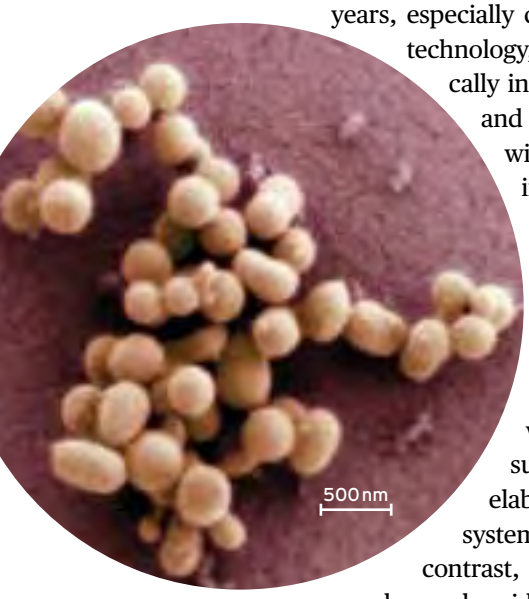
LightSails™ as the 100 Year Starship™

IT SEEMED A BIT INCONGRUOUS when the U.S. Department of Defense—specifically, the Defense Advanced Research Projects Agency (DARPA)—initiated a program called the 100 Year Starship™ (100YSS) based on a vision of interstellar flight. It is the brainchild of David Neyland, a program director at DARPA, and Pete Worden, director of the NASA Ames Research Center. They were inspired by Robert Heinlein's novel *Time for the Stars*, in which entrepreneurs create the Long Range Foundation, which invests in space travel to spur innovative science and technology. DARPA wants to spur such innovation and trademarked the name 100 Year Starship with the intention of licensing it to the winner of a study competition focused on creating a nongovernmental, privately funded organization with that goal. The winner of the competition was the Jemison Group, under the leadership of former astronaut Mae Jemison.

The 100 Year Starship concept was first discussed at an invitation-only strategic planning workshop in January 2011 and again nine months later at a symposium in Orlando, Florida. The three authors of this article, as participants at the workshop and subsequent symposium, urged the attendees to consider that the future of interstellar travel might be less about sending humans on long voyages and more about sending human surrogates that incorporate advances in robotics, biology, and information processing. J. Craig Venter, a forward-thinking scientist and entrepreneur in the field of DNA synthesis, suggested that interstellar flight might include DNA molecules programmed to interact with the target planet

and send information back in ways we can only begin to imagine.

Human exploration of other star systems will occur only if we leave humans at home. Nano-spacecraft will make interstellar journeys instead of monster-sized vehicles powered by a nuclear, antimatter, or warp drive. Consider how little the development of human spaceflight technology has changed over the past 50 years, especially compared with robotic space technology, which has evolved dramatically in intelligence, lifetime in orbit, and data collection capability, with resulting improvements in distance traveled and scientific value. Humans have not yet traveled beyond the Moon, and ideas for extending human spaceflight farther into the solar system are the same now as they were in the 1960s—requiring supersized rockets, lots of fuel, elaborate and heavy life-support systems, and long flight times. In contrast, robotic technologies have advanced rapidly, following a path somewhat in congruence with Moore's Law (describing exponentially fast advances in electronics and computational technology, with a doubling of capability every 18 months), with the result that our robotic probes have achieved flight to the far reaches of the solar system and their sensors and instrumentation now have hugely increased capabilities with less volume, mass, and energy.



ABOVE
Symposium attendee J. Craig Venter suggested that the most practical way to send Earthlings to the stars might be to send human surrogates in the form of DNA molecules programmed to gather and return information from the mission's destination. Venter has already created M. mycoides JCVI-syn 1, *the first synthetic, self-replicating bacterial cell.*

In this article, we describe an incremental approach to interstellar flights that utilize those advances in robotic technology and consequently are fast, economical, and technically feasible (no miracle breakthroughs required).

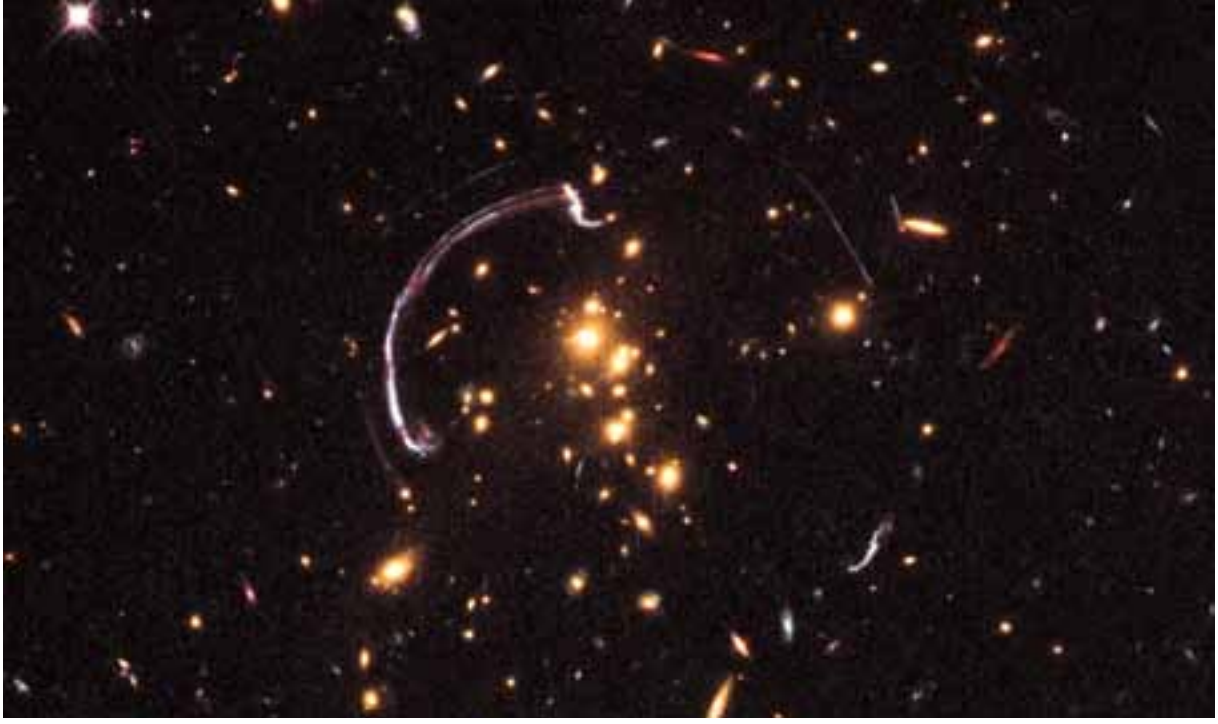
SMALL AND SAIL-POWERED

Practical interstellar flight may be achieved in one century. Precursor missions flown in the next decades can serve as milestones on the way to the stars. The key is to send nano-spacecraft with solar sails close to the Sun in order to produce the acceleration needed to escape the solar system at high speeds. Nano-spacecraft today have limited payload and communications capabilities, but that situation is changing rapidly, in part due to The Planetary Society's *LightSail* development. Even now, a study led by the Jet Propulsion Laboratory is looking at possible interplanetary missions based on the *LightSail* spacecraft for the NASA Innovative Advanced Concepts program.

Lightsailing to the stars on laser beams was conceived by Robert Forward during the 1980s as the only known practical method for achieving interstellar flight. Using this approach, laser (or microwave) beams focused over interstellar distances would provide the continuous push needed after sunlight runs out as a useful light source. (Solar emissions become too weak at distances beyond the orbit of Jupiter.) This method eventually requires construction of a large laser platform in the solar system. Here we are suggesting that pure solar sailing can be used both to advance interstellar flight technology and to achieve interim flight milestones.

The first proposed application of solar sails for interplanetary propulsion goes back to a suggestion by Jerome Wright in the 1970s for a mission to rendezvous with comet Halley. The extraordinary part of his idea arose from the need to match the direction and speed of an object that was falling into the inner solar system along a retrograde, or "backward," path, opposite the direction of planetary orbits. To put the spacecraft on this trajectory required a kind of "stop the world, I want to get off" maneuver. Achieving the reversal of angular momentum was to have been accomplished by continuous acceleration

LOUIS FRIEDMAN, *emeritus executive director of The Planetary Society, is the* LightSail *program director.* **TOM HEINSHEIMER** *has had a long and varied career getting things off the ground, beginning with the* Mercury *and* Apollo *programs. In the 1980s and 1990s, Tom lent his support to The Planetary Society's* Mars Balloon *and* Marsokhod *rover. He's now Managing Director of his consulting firm, Colbaugh & Heinsheimer.* **DARREN GARBER** *has supported design, development, and operations for numerous precision space missions for more than 15 years. He has a BS in astrophysics from Ohio State University and an MS in astronautical engineering from the University of Southern California, where he is completing his PhD in astrodynamics.*



LEFT *An interesting point from which to study exoplanets on our way to the stars might be the gravity lens focus made possible by our Sun. A gravity lens occurs when the gravitational field of a foreground object bends and amplifies the light of a more distant object. In this example of the gravity lens effect, the light from a galaxy almost 10 billion light-years away has been warped into a nearly 90-degree arc of light in the galaxy cluster RCS2 032727-132623. The galaxy cluster is only 5 billion light-years away. This natural-color image was taken in March 2011 by the Hubble Space Telescope.*

SEM Image: J. Craig Venter Institute; Image: NASA, ESA, J. Rigby (Goddard Space Flight Center), K. Sharon (Kavli Institute for Cosmological Physics, U. of Chicago), and M. Gladder and E. Wuyts, U. of Chicago

from sunlight and a trick of celestial mechanics. That is, applying a velocity increase (changing the probe's orbit energy, or angular momentum) is most efficiently done at its closest point to the Sun (perihelion). The smaller the perihelion distance, the more the spacecraft's energy can be increased. The strategy for the Halley rendezvous called for repeated close orbits of the Sun and adjustments to the probe's angular momentum until it was flipped over and matched the comet's retrograde motion.

For interstellar flight, we will use a similar strategy of close flybys of the Sun (low perihelion) to get a large energy change. In addition to this celestial mechanics advantage, the spacecraft also will gain more light power to push the sail when it passes close to the Sun. The energy change increases the size of the spacecraft's orbit, extending its aphelion (farthest point from the Sun) beyond the outermost planets. In this way, the aphelion can be extended to infinity, and the spacecraft will attain a hyperbolic (instead of elliptical) orbit that escapes the solar system.

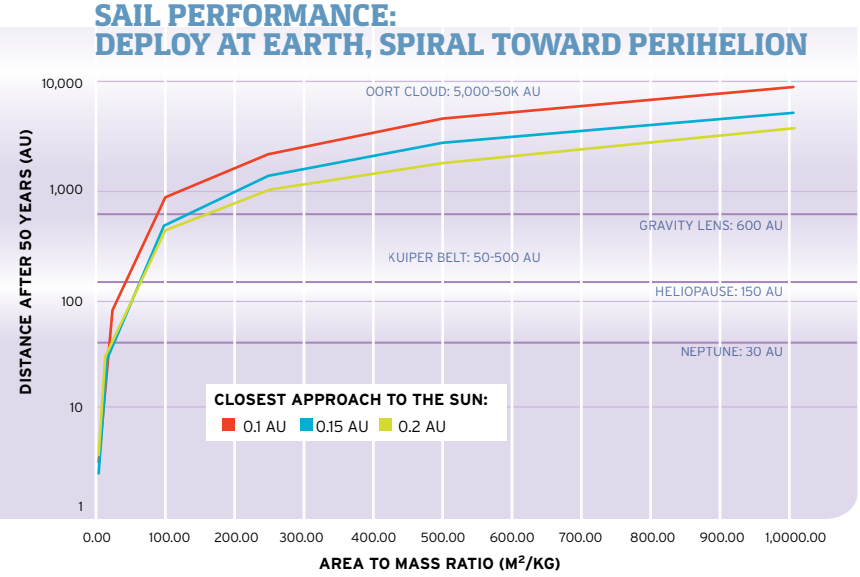
To achieve high escape velocities, we need a large ratio of sail area to spacecraft mass (A/m). A big sail area collects lots of photons, and each photon transfers energy to the spacecraft. The lower the mass of the spacecraft, the larger the resulting acceleration. Another key factor, as noted earlier, is closeness to the Sun. The perihelion distance is constrained by the thermal properties of the spacecraft and the sail. A sail at 1 Astronomical Unit (AU), the distance of the Earth from the Sun, only has to withstand approximately 45 degrees Celsius (113 degrees Fahrenheit), but at 0.3 AU, the sail has to withstand about 305 degrees Celsius (581 degrees Fahrenheit). We will want to go even closer to the Sun. Mylar cannot perform in those conditions, but certain polyimide plastics can. Really advanced materials made of carbon nanotubes and fibers or with aluminized substrates that evaporate, leaving an ultra-thin sheet of aluminum molecules, also may enable closer solar flybys. Thus, the search for an interstellar propulsion system will include finding the best possible material to make the sail.

HOW FAR, HOW FAST?

The distance to the farthest planet, Neptune, is about 30 AU. The Kuiper belt of icy objects, many of which are dwarf planets or inactive comets, extends from about 50 AU to 500 AU. The boundary of the solar system usually is designated as the heliopause, a broad and irregularly shaped area where the stream of particles emitted by the Sun gives way to the stream of particles from other stars (cosmic radiation). The heliopause is roughly 150 AU from the Sun. No spacecraft from Earth has reached this distance, although *Voyager 1*, the fastest thus far, is reaching the end of the heliosheath, the transition region where the solar wind interacts with cosmic radiation. *Voyager 1* will soon reach the heliopause, traveling approximately 3.7 AU/year. (For reference, 1 AU per year equals 4.73 kilometers per second, or about 17,000 kilometers or 10,500 miles per hour.)

The nearest star (besides the Sun) is Alpha Centauri, about 4.3 light-years distant. With 1 light-year being equal to 63,000 AU, Alpha Centauri is 271,000 AU from the Sun. It will take *Voyager 1* about 17,000 years to go one light-year.

To determine how far a nano-spacecraft powered by a solar sail could go in a given time, we performed a



ABOVE *By increasing the ratio of sail area to weight, and by pushing the craft closer to the Sun to get a better "boost," we can speed the mission out past the solar system and into the unknown.*

parametric analysis of Area/mass ratios (area of the sail to the mass of the spacecraft) and closest approaches to the Sun (perihelion distances). We considered A/m ratios from about 1 m²/kg (approximating the Japanese *IKAROS* spacecraft) to about 1,000 m²/kg. (As a comparison, the proposed value for the Halley Comet Rendezvous was 700 m²/kg.) The Planetary Society's *LightSail* is about 7 m²/kg. For readers interested in the technical details, we define the "characteristic" acceleration of the spacecraft as the acceleration at 1 AU.

As a first step, scaling up the *LightSail* spacecraft, we might consider an area-to-mass ratio of about 100 m²/kg–for example, a 100 × 100-meter sail and a spacecraft mass of about 100 kg (equivalent to a large washing machine). However, the real future for interstellar flight will require spacecraft mass to be an order of magnitude smaller for a sail this size, yielding an A/m value of about 1,000 m²/kg. Chinese mission analysts recently proposed a solar sail spacecraft for asteroid deflection with a value of 550 m²/kg.

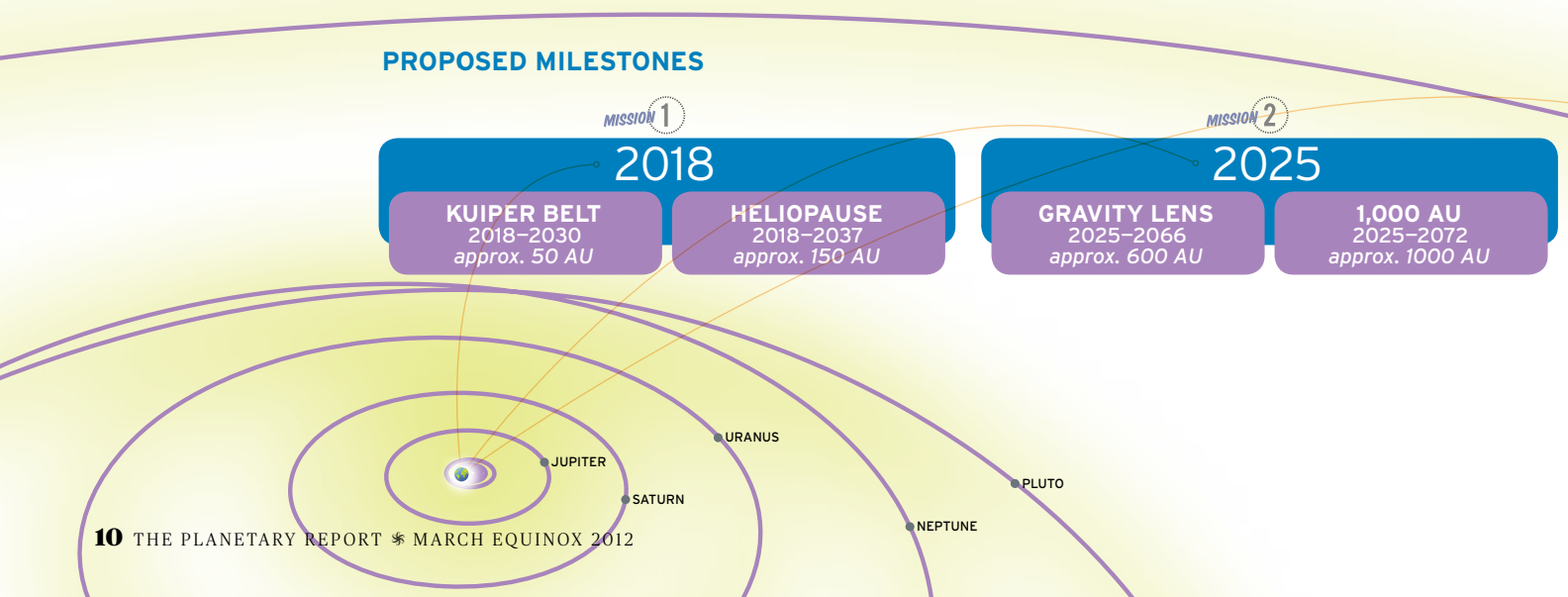
For the closest approach to the Sun, we considered perihelion values in the range of 0.1-0.2 AU. This is really close. In the 1970s, the Halley Comet Rendezvous study considered 0.25 AU. More recent NASA studies for a solar probe suggest that advances in materials will permit even closer survivable approaches.

The solar sail is deployed after launch, and the spacecraft spirals toward the Sun. At perihelion, the sail is repositioned to maximize aphelion, and the spacecraft continues to orbit the Sun until solar system escape is achieved. Once the spacecraft is past the orbit of Jupiter, the sail can be jettisoned. The Sail Performance graph at left shows how far a solar sail spacecraft can get in 50 years as a function of A/m and perihelion distance.

OUT TO THE GRAVITY LENS

In 50 years, our spacecraft with A/m = 100, on a trajectory to pass within 0.2 AU of the Sun, reaches 450 AU, nearing the outer edge of the Kuiper belt, and with a 0.15 AU trajectory it reaches 500 AU. However, if the perihelion is as close as 0.1 AU, the spacecraft reaches 900 AU! The advantage of a closer perihelion becomes even greater with increases in the ratio of sail area to spacecraft mass. The figure shows potential milestones as spacecraft design evolves, expanding sail area and reducing mass–from Neptune on out to the Oort cloud, where comets are believed to form.

The gravity lens focus is a particularly interesting



milestone on the way to interstellar flight. It is the location where light from a distant source is focused after being bent by the Sun's gravity (as predicted by Albert Einstein in the General Theory of Relativity). Thus, the gravity lens focus might be a good place from which to study exo-worlds. The theoretical focus is a line starting at 550 AU, but solar corona effects move it out to approximately 700 AU (and beyond, because the focus then extends to infinity). In the figure below, we use 600 AU as a nominal value. An A/m = 100 spacecraft with a perihelion of 0.15 AU reaches this distance in 55 years, escaping the solar system at a speed of about 19.4 AU per year. If the perihelion is 0.2 AU, the flight time is extended about 25 percent. Conversely, if the perihelion can be as low as 0.1 AU, then the flight time might be halved. In this case, we might reach the gravity lens distance of 600 AU in 25-30 years.

The Proposed Milestones figure presents a series of possible destinations for 100 Year Starship missions. The timelines all assume trajectories with a perihelion of 0.15 AU, but we also assume steadily improving spacecraft parameters from advances in nanotechnology. Solar sails will get thinner, and sail areas will grow from our present 5 × 5-meter sail to 30 × 30-meter sails in three steps. Booms will become lighter and stronger, probably using carbon nanotube material in the latter stages. As technology advances, mass in relation to sail area decreases below the nanospacecraft level to 1 kilogram, or pico-spacecraft, size.

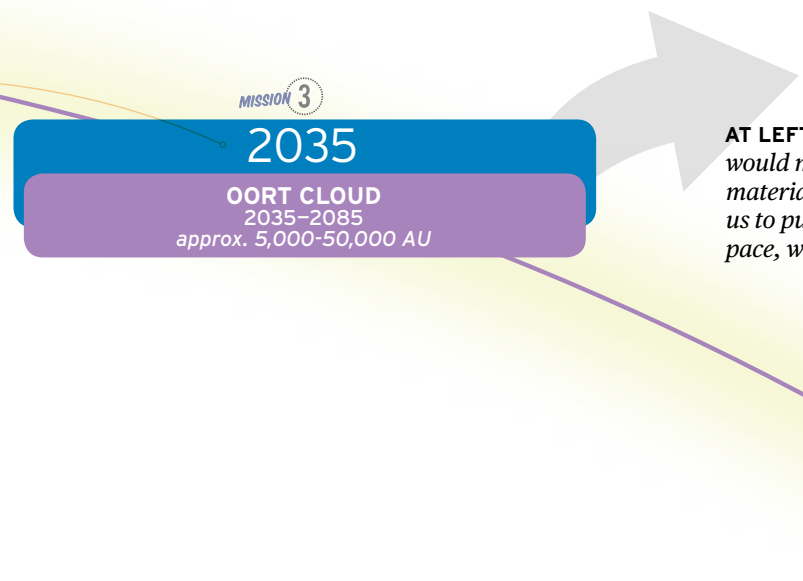
Satellites this size already are being studied and designed at Aerospace Corporation. We submit that our 100 Year Starship interstellar precursor proposals, although speculative, are realistic. With a doubling of capabilities every decade, we can reach farther and farther beyond our solar system. This perspective suggests a type of Moore's Law for spaceflight, driven not by markets but by a vision of understanding our place in the universe.

The three missions suggested in the figure below are a 2018 mission to the Kuiper belt and then on to the heliopause, a 2025 mission to the gravity lens and then out to 1,000 AU (perhaps along the gravity lens focus), and a 2035 mission to the Oort cloud, in which the spacecraft would study intermediate destinations and reach its final target by 2085. In terms of scientific value, a flight through the Kuiper belt will build on the myriad discoveries by *New Horizons* missions, and the heliopause will require multiple flybys to characterize the physics there. The mission to the gravity lens will open views of the universe that are impossible from within the solar system.

ABOVE *For generations, we have dreamed of going to the stars. The authors believe that the fastest way to achieve interstellar flight is to remove most of the weight from the craft, and send unmanned missions out past the solar system.*

LONG-TERM THINKING

Our three proposed missions will be precursors to interstellar flight both as technical milestones, providing specific goals for going farther and faster, and as technology steps, delivering new *LightSail* technology that someday will take us to the stars. From today's perspective, reaching a 1-light-year milestone, let alone the Alpha Centauri distance of 4.3 light-years, seems beyond the capability of pure *LightSails* without laser or other beaming. However, nanotechnology, materials science, and robotics are advancing

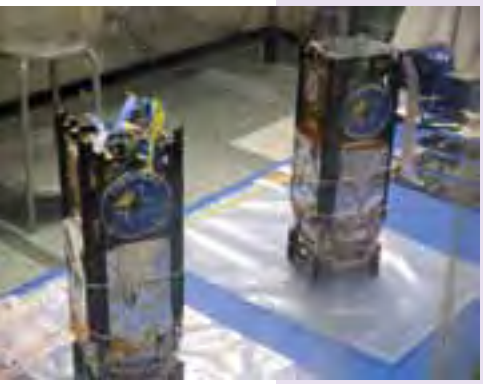


AT LEFT *The three proposed missions would make use of better and better materials and technology, enabling us to push farther out, and at a faster pace, with each successive spacecraft.*

THE SOCIETY'S ROLE

LightSail™ Ready and Waiting for a Ride

The Planetary Society's *LightSail™* spacecraft has been assembled, tested, and stored in a clean room. It now waits for the next available rocket to the right orbit. Once it is aloft, the mission of the 4.9-kilogram (10.8-pound) spacecraft will be to demonstrate technologies that can be refined for nano-spacecraft that may soon travel toward the stars.



ABOVE
LightSail-1 *and its twin backup spacecraft sit in the clean room, ready for storage. We now await a launch vehicle to give us a ride to Earth orbit.*

LightSail has a complete attitude control system (unusual in a spacecraft this size) and six ultra-small accelerometers, which this mission will test in space for the first time. The accelerometers will sense the force of sunlight that pushes against the spacecraft's sail, enabling direct measurements of acceleration. As the sail is adjusted to increase acceleration, changes in the spacecraft's orbit will be measured by a global network of amateur astronomers, who will record the time and viewing angles of *LightSail* overflights. In addition, the craft has two video cameras to watch the 5.65 × 5.65-meter (18 × 18-foot) aluminized Mylar solar sail as it deploys on motorized steel booms from the hub of the spacecraft. The cameras will continue observations of sail dynamics as the spacecraft is repositioned to increase orbit energy.

Getting a ride to space is now the major remaining task. Secondary payload opportunities are fairly frequent (several per year), and *LightSail* is an easy module to take aboard using the CubeSat deployment system. CubeSats are small, standardized payloads, often used for student projects but increasingly employed for focused, low-cost science and technology investigations. *LightSail* needs a ride to an orbit high enough that atmospheric drag is negligible. Depending on solar activity (which heats up the atmosphere), the orbit should be at a height of about 800 kilometers (500 miles). Launches to this altitude are less frequent, and until the right opportunity is identified, *LightSail* will be stored in a sealed, nitrogen-filled box. About three months before launch, it will be rebooted with software updates and will undergo a final functional test. The spacecraft will then be enclosed in the standard CubeSat launch interface, the Poly Picosatellite Orbital Deployer (P-POD).

LightSail is ready for launch, which we hope will take place this year. The Society has a spare spacecraft ready as a backup; it would be available for an additional mission after the first *LightSail* launch. The project is paid for by donations from Members of The Planetary Society. This first-ever privately funded solar sail is part of the Society's broader mission to create and nurture a global community that is committed to exploring the planets, studying the universe, understanding the Earth, and searching for life. *–LDF*

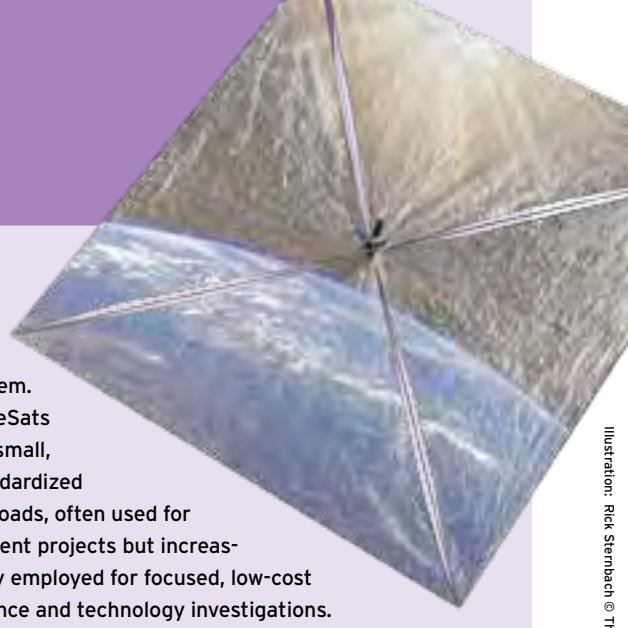


Illustration: Rick Sternbach © The Planetary Society; photo: Louis Friedman

so quickly that we do not rule out this goal and intend to study it further.

There is much work to be done toward the development of nano-spacecraft. We need to communicate with our spacecraft, and they will need a small amount of onboard power for instrumentation. We do not yet have complete solutions for these challenges, although there are already possibilities in LEDs, optical communications, miniature radioisotope generators, and nanobots using chemical and biological processes. Even without knowing how they will take form, we bet on these technology improvements as the most likely ways to extend human presence beyond the solar system.

The lure of interstellar flight should not be underestimated. Whether or not extraterrestrial life is found in our solar system, there is a human drive to understand our place in the universe. The extraordinary variety of planets has whetted the desire to find and ultimately explore habitable worlds—worlds that may harbor life that evolved independently of Earth's.

The magnitude of space is daunting, and interstellar flight may seem as far from the capabilities of our generation as aerodynamic flight was from DaVinci's. Thinking small, however, can bring the vastness within our reach, and nano-spacecraft can extend human awareness virtually into worlds in other solar systems.

Habitable Zones

AN INTERNATIONAL TEAM OF SCIENTISTS has announced that rocky planets not much bigger than Earth are probably very common in the habitable zones around faint red stars in the Milky Way. This is the first direct measurement of the frequency of super-Earths around red dwarfs, which account for 80 percent of the stars in the Milky Way. The team made the discovery using observations taken with the High Accuracy Radial velocity Planet Searcher (HARPS) spectrograph on the 3.6-meter telescope at the European Southern Observatory's La Silla Observatory in Chile.

"Our new observations with HARPS mean that about 40 percent of all red dwarf stars have a super-Earth orbiting in the habitable zone where liquid water can exist on the surface of the planet," says team leader Xavier Bonfils from IPAG, Observatoire des Sciences de l'Univers de Grenoble, France. "Because red dwarfs are so common–there are about 160 billion of them in the Milky Way–this leads us to the astonishing result that there are tens of billions of these planets in our galaxy alone."

"The habitable zone around a red dwarf, where the temperature is suitable for liquid water to exist on the surface, is much closer to the star than the Earth is to the Sun," cautions team member Stéphane Udry of the Geneva Observatory. "But red dwarfs are known to be subject to stellar eruptions or flares, which may bathe the planet in X-rays or ultraviolet radiation, and which may make life there less likely."

–from the European Southern Observatory

Illustration: ESO/L. Calçada

ABOVE *Sunset might look like this on Gliese 667 Cc, one of billions of rocky planets that orbit red dwarfs in our galaxy. The brightest star in the sky is red dwarf Gliese 667 C, part of a triple-star system. The more distant Gliese 667 A and B glow to the right.*

Air on Dione?

CASSINI **HAS DETECTED MOLECULAR** oxygen ions around Saturn's icy moon Dione for the first time, confirming the presence of a very tenuous atmosphere. At Dione's surface, this atmosphere would be only as dense as is Earth's 300 miles (480 kilometers) above the surface. Dione's oxygen ions are sparse (one for every 0.67 cubic inches of space, or 90,000 per cubic meter), so the moon has an extremely thin neutral atmosphere.

"We now know that Dione, in addition to Saturn's rings and the moon Rhea, is a source of oxygen molecules," says Robert Tokar, a *Cassini* team member based at Los Alamos National Laboratory in New Mexico. "This shows that molecular oxygen is actually common in the Saturn system and reinforces that it can come from a process that doesn't involve life."

–from the Jet Propulsion Laboratory

CHARLENE M. ANDERSON
for The Planetary Society.

ABOVE *The city of Helium, also called The Jewel of Barsoom (Mars), is the home of Princess Dejah Thoris in the John Carter of Mars books.*

John Carter of Mars:

Science Fiction Triggers a Love of Space

A SOUTHERN GENTLEMAN weary of war, four-armed warriors standing 12 feet tall, and a naked princess in need of a champion, all striving to survive on a dying planet—these are the central elements from which Edgar Rice Burroughs created his classic science fiction series featuring the intrepid hero John Carter of Mars. Burroughs's first novel, *A Princess of Mars*, appeared in 1912, followed by 10 more books in the series. The John Carter books have proved to be among the most beloved and influential in science fiction history.

Within The Planetary Society, we felt John Carter's persistent influence when we asked you, our Members, what triggered your passion for space exploration. "Reading science fiction" was a top answer, and many, many, many of you cited the John Carter of Mars books as the ones that first turned your gaze outward to the planets.

When we heard that the first John Carter book was being made into a feature film by Andrew Stanton, who wrote and directed both *Finding Nemo* and *WALL-E*, we knew you'd be interested. And when the chance came to interview Stanton, we jumped at it, as you'll read below. —*Charlene Anderson*

Of all the possible science fiction heroes out there, why did you choose to make a film about John Carter, who was introduced a hundred years ago?

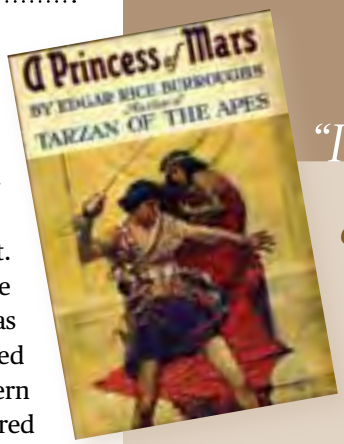
I fell into awareness of the book when I was 11, which was the prime age to discover that

book for anybody of any generation of any era. It might as well have been written in 1976, when I read it. I didn't take it as science fiction–the way people interpret that term–but as a romantic adventure in undiscovered country. When I grew up in the modern era, every inch of Earth had been explored and mapped. But the book reflects the romanticism of the previous centuries, when there was always some part of the world yet to be discovered–new peoples, cultures, and lands. With the advent of better telescopes, people looked upward to continue to hope to find more undiscovered areas. That was the biggest attraction to me and made me continue from one book to the next to find out more about another city, another culture, another creature, another character, another society on these new continents that existed on Mars.

What role does the planet Mars play in the story? It's a world we've now landed spacecraft on; we have close-up pictures of its surface. How did you create the character of Mars?

I set the movie on turn-of-the-century Mars. Nobody can disprove what was going on then. It's up to people's imaginations about what changed between then and now. I felt I had complete license to stick with Edgar Rice Burroughs's vision and make it as believable as possible, considering that there's some license that you're taking just to have the fantasy occur. I made rules that the planet was older and further advanced in civilization than we were, so it gives us a glimpse of the future degradations of the planet and its societies. Again, I tried to keep the romantic nature that was in the books, with parallel civilizations evolving on different planets that weren't connected to each other. Earth might have discovered some things sooner than Mars and vice versa. Mars *is* the movie–it doesn't play a role.

continued...



"I Journeyed With John Carter..."

Carl Sagan, Barsoom, and Edgar Rice Burroughs

The year 1980 was a watershed for many who dream about the possibilities to be found in space. That year, The Planetary Society was launched, and *Cosmos: A Personal Voyage*, hosted by Planetary Society cofounder Carl Sagan, aired on television for the first time.

In the fifth episode of *Cosmos*, "Blues for Red Planet," Carl explored the fascination so many of us feel with the planet Mars. Among the televised moments I remember best is when Carl recounted how he began to wonder if it were possible to travel to other worlds, speculation triggered by reading Edgar Rice Burroughs's novels about John Carter of Mars.

> **I can remember reading with breathless fascination the Mars novels of Edgar Rice Burroughs. I journeyed with John Carter, gentleman adventurer from Virginia, to "Barsoom," as Mars was known by its inhabitants, wandering among the beasts of burden, called thoats; winning the hand of the lovely Dejah Thoris, Princess of Helium; and befriending a ten-foot-high green fighting man named Tars Tarkas, as the moons of Mars hurtled overhead on a summer's evening on Barsoom.**
>
> **It aroused generations of eight-year-olds, myself among them, to consider the exploration of the planets as a real possibility, to wonder whether we ourselves might one day venture to the distant planet Mars. John Carter got to Barsoom by standing in an open field, spreading his hands and wishing hard at Mars. I can remember spending many an hour in my boyhood, arms resolutely outstretched in an empty field in twilight, imploring what I believed to be Mars to transport me there. It never worked. There had to be some better way.**
>
> –From Episode 5 of *Cosmos: A Personal Voyage*, written by Carl Sagan, Ann Druyan, and Steven Soter

There was a better way to get to Mars, and we used it. Chemical-powered rockets launched robotic explorers on their way to the Red Planet, where they flew by, orbited, and landed on a Mars very different from the world portrayed by Burroughs. The eight-year-old Carl Sagan grew into a world-renowned scientist who came to know the real Mars extraordinarily well and still dreamed of the day when explorers from Earth, equipped with technologies Burroughs never knew, would place real footsteps on the plains of Mars. –CMA

Percival Lowell

Percival Lowell and Our Fascination with Mars

The planet Mars has long exerted a strong hold on the human imagination. For almost 50 years, scientists have been aiming their robotic probes at this neighboring world, and for decades, visionaries have been seriously sketching out steps toward its colonization. Mars has excited the artistic imagination as well, becoming a favored otherworldly setting for works of literature and film since H. G. Wells's *War of the Worlds* appeared in 1898.

Why this fascination with Mars? It is my belief that the praise or blame for Mars' popularity can be laid at the feet of Percival Lowell, the American millionaire and astronomer who built himself a powerful telescope on top of an Arizona mountain and made it his life's work to map the surface of Mars. As part of that work, he wrote books and countless articles about Mars, traveled the world lecturing to an enraptured public about the planet, and inspired writers like Wells and Edgar Rice Burroughs to populate Mars with creatures of their imaginations and invite their readers to explore the possibilities with them.

Today, Percival Lowell usually is remembered as the guy who mistakenly believed Mars was crisscrossed by canals built by a dying civilization on a desiccating planet. For us, with the benefit of more powerful telescopes and spacecraft that have flown by, orbited, and landed on Mars, it's easy to ridicule Lowell for his mistakes. I've known scientists who blamed Lowell for raising the public's expectations too high concerning findings of life there. The reasoning goes that, when landers like *Viking* failed to find life, the public felt so disappointed that most lost interest in Mars.

I feel more charitable toward Lowell. It was his tireless popularization that excited people around the world about what might be waiting for us on Mars. More spacecraft have been aimed at Mars than at any other planet. There are many reasons for this—such as the possibility of life, the planet's similarity to Earth, and the hope that humans might one day walk there—and Lowell did a great job priming the public to support the exploration of Mars.

Filmmaker Andrew Stanton dipped into Lowell's writings while preparing *John Carter*, knowing that Edgar Rice Burroughs, who created the character John Carter of Mars, had been inspired by Lowell. The millionaire astronomer thus continues to feed our fascination with Mars, and I, for one, am grateful to him for that. —*CMA*

photo and map: Lowell Observatory Archives

Do you see romance in modern attempts to explore Mars and other planets?

The very notion of having the gumption to jump into the abyss and to see what's out there is quite a romantic, optimistic notion. Again, I grew up just in time to have enough recollection of the manned landings, of walking on the Moon. Space exploration was all the rage, where things were going to go. We were seeing it in real life, let alone in literature and the media and the movies. The idea of conquering new unknown territory is very romantic in its DNA.

Do you think modern, more scientific views of Mars influenced the Mars you created?

It's my hope—and this is in the fan, not the filmmaker—that this movie will do well enough that the whole series eventually will be made. I love the idea of seeing how much knowledge that we've gleaned from the actual Mars, and will continue to glean, can be incorporated without having to derail where the stories went. One of the things I can incorporate is the actual topography. It is fun to look on my laptop or even my iPhone and see the exact topography. I can Google "Mars" and get the elevations, the names of the locations, and I can apply all the Barsoomian titles and names and places that Edgar Rice Burroughs made up and try to align them in the hope that we can be even more scientifically accurate on whatever things we can be.

Both Burroughs and H. G. Wells took a lot of their inspiration from Percival Lowell's concept of Mars, the dying planet. Did you seek out Lowell's books and maps when you were preparing for the film?

We did! Again, more to glean the sense of the time, of the limited scope people had at the time, of a blank slate that people wanted to fill in. The perfect example is, with the limited telescopes, they saw all these lines on Mars that they had never seen before, and people began to conjecture that they might be canals. Fiction writers could wonder, what if they were literally canals that were built? I loved that there's this sense of wonderment about what's the full equation of what we're looking at out there. I have a first-edition copy of Percival Lowell's book, and we've used some of his studies as part of our main title sequence.

ABOVE *Tars Tarkas (center, played by Willem Dafoe) prepares for a duel as John Carter (right, played by Taylor Kitsch) looks on in Disney's feature film* John Carter. *Tars Tarkas is a member of the brutal Tharks, the four-armed race of Martians that lives on Burroughs's Barsoom.*

Do you think science fiction, like the John Carter books, can play a role in inspiring young people to make space exploration their life's work?

I definitely think so. The sad case is that you're not seeing science as robust and as supported in real life. They once fed off each other. These science fiction artists and novelists were inspiring the wannabe scientists, and then the advances in science and exploration fueled the artists. I see that every day at Pixar between art and science—they ping-pong off each other. Right now, it feels as though one player is being forced to take a rest. That's the sad thing that I see, that we can be inspired by the fiction aspect of it but not see a balance in the fact of it.

Do you have a desire to go to Mars yourself and see what might be there?

I'm too nervous a traveler to make it that far. If somebody could jaunt me right there, I would be first in line.

So you like the method of transport that Edgar Rice Burroughs came up with?

The astral projection is not a bad way to go.

CHARLENE M. ANDERSON
for The Planetary Society.

Save Science in NASA

The Battle Has Begun

YOU AND I AND ALL PLANETARY SOCIETY MEMBERS are well aware of the economic problems facing nations around the globe. We know that government spending cannot remain at the levels we once took for granted, and we accept that cuts will be made. The questions become which programs will be cut so that others may thrive and whether the right cuts are being made.

In early February, the U.S. administration released its proposed budget for fiscal year 2013. For those of us who care about science and planetary exploration, the proposed cuts to NASA's science program would be devastating.

NASA's science budget would be cut, with the biggest chunk coming out of planetary science, which stands to lose a whopping 20 percent of its funding, falling from $1.5 billion this year to $1.2 billion next year. NASA managers baldly state that there is no money for flagship missions, such as the long-sought Europa orbiter. Singled out for a breathtaking slash is the Mars program, which will lose 39 percent of its funding, falling from $587 million to $360 million in the next year.

MARS EXPLORATION SQUEEZED HARD

"The Mars program is one of the crown jewels of NASA," ScienceInsider quoted Ed Weiler, the former head of NASA's science program. "In what irrational, Homer Simpson world would we single it out for disproportionate cuts?"

Here's the immediate effect: NASA backed out of a partnership agreement with the European Space Agency (ESA) to share work and costs on the Trace Gas Orbiter, to launch in 2016, and the ExoMars rover, in 2018. In response, ESA has turned to Russia and invited Roscosmos to be a full partner, filling the void left by NASA.

In the last 12 months, NASA has backed out of five partnerships with ESA: besides the Trace Gas Orbiter and ExoMars rover, there was the LISA Gravity Wave Observatory, International X-Ray Observatory, and Europa-Jupiter System Mission. You can't help but wonder if international partners will ever trust NASA again.

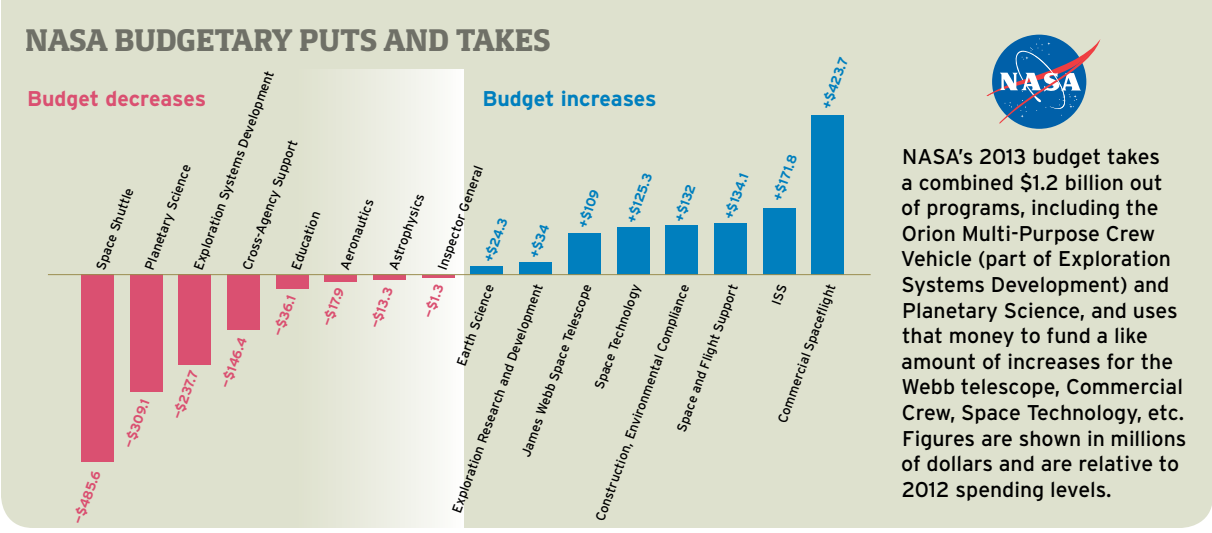
The claim is that NASA is changing its Mars exploration strategy to more closely align science with the human spaceflight program. In this proposal, the Science Mission Directorate (SMD) will share the costs with the Human Exploration and Operations Mission Directorate (HEOMD) and the Office of the Chief Technologist (OCT). Right now, a "tiger team" is figuring out how to meld the desires of the different directorates into a single robotic mission to Mars in 2018. But here's the rub: after backing out of five partnerships with ESA, NASA says it is going to "actively seek the collaboration of our international partners."

FLAGSHIP MISSIONS WILL BE GONE

As the proposed budget was rolled out, NASA Administrator Charlie Bolden repeated in countless briefings that his agency can no longer afford the ambitious "flagship" missions that once made its science program the pride of people around the world. In this new vision, there will be no more great missions of discovery to the outer planets, ones like *Voyager*, *Galileo*, and *Cassini*. There will be no Mars Sample Return mission, such as that given top priority by the U.S. National Research Council's Decadal Survey for Planetary Science.

That council brought together a committee of top scientists, who were tasked by NASA to rank the priorities for the next missions to other worlds. In evaluating potential flagships, the survey committee gave Mars Sample Return first ranking and a Europa orbiter second. They acknowledged the high costs of flagship missions and called for the missions to be "de-scoped" and made more affordable. The planetary community responded with more modest (and less expensive) proposals under this new budget, but it doesn't matter–all flagships are gone.

Consider that possibility. There will be no great missions of discovery in NASA's future, nothing of the caliber of *Viking* and *Voyager*, *Galileo* and *Cassini*. The



Graph data from Space News Research

United States is walking away from decades of greatness in planetary exploration.

The decadal survey, which NASA itself asked the planetary community to provide, will be tossed aside. The scientists and engineers who have laid out detailed and thoughtful plans to advance our knowledge of other worlds will watch their NASA support trickle away.

IS THE SEARCH FOR LIFE OVER?

NASA seems also to have set aside the longtime, and publicly popular, organizing theme of searching for life on other worlds. Thanks to NASA's science missions, we now know that liquid water, that essential medium for life as we know it, once flowed in abundance across Mars. Scientists strongly suspect that Jupiter's moon Europa, with its under-ice liquid ocean, possesses the ingredients to support life.

The missions designed to seek out evidence that life once flourished or continues to exist on other worlds will be gone. If this budget for NASA is allowed to stand, you and I may never know if we share this solar system with any other living creatures.

WHAT IS THE SOLUTION?

The Planetary Society has carefully thought through the ramifications of this budget. The Society is urging, with your help, that NASA's budget be rebalanced to put resources where they can be most effective in achieving NASA's mission as stated in its charter: the expansion of human knowledge. NASA's budget should be adjusted so that science is brought up to at least 30 percent of the total each year, which will enable the agency to carry out the great missions of discovery.

Consider these numbers: NASA's total 2013 budget is down only 0.3 percent from last year, but the science budget took a disproportionate 3.2 percent cut, and its share of the pie has fallen from 28.5 percent of the total to 27.7 percent. Meanwhile, human spaceflight accounts for 45 percent of NASA's budget and is set to go up nearly 0.5 percent this year, even though costs for the retired shuttle declined by nearly $500 million. Here, NASA is doing less, but with more money. For science to be put at 30 percent of NASA's top-line budget, the administration needs to lift it only 2.3 percent, $400 million. That extra $400 million could put Mars science and flagships back on track.

Where can the money come from? From the retired space shuttle, for starters. Several years ago, the science program was cut by several billion dollars to cover the cost of returning the space shuttle to flight, so it seems right that science be paid something back. In addition, there is one well-funded program in NASA that, unlike the threatened planetary science missions, has no well-defined goal, is being built with leftover parts, and was designed by a few U.S. senators to protect jobs in their states: the Space Launch System. The Planetary Society remains a staunch advocate of human spaceflight, but the current program lacks a clear goal and a credible plan that would merit the proposed budget. Unless, and until, a credible human exploration program is brought forward, science provides the best value for the money.

WHAT CAN YOU DO TO CHANGE THIS?

You can help The Planetary Society save this science in NASA. Already, we've started making the case to the administration, talking to members of Congress and their staffs, writing op-ed pieces, giving interviews, and making it clear to the decision makers in Washington, D.C. that we won't let them slash science.

You will soon be receiving by mail a petition that calls on the U.S. Congress and the administration to restore funds for NASA science. If its budget share is increased to 30 percent, you can still hope to see ambitious missions to Mars, look forward to a return to the outer planets, and continue the search for life on other worlds.

Together, we can keep exploring the planets.

Planets Around Alpha Centauri?

Society Funds Help Support Planet Search

DO PLANETS CIRCLE A system loved by science fiction—our closest stellar neighbors, Alpha Centauri? We don't know, but Debra Fischer, Julien Spronck, and their colleagues at Yale University, in part with Planetary Society support, are trying to find out.

RIGHT *Debra Fischer and Julien Spronk at work on the 1.5-meter telescope at Chile's Cerro Tololo Inter-American Observatory.*

Photo: Zachary Kaplan

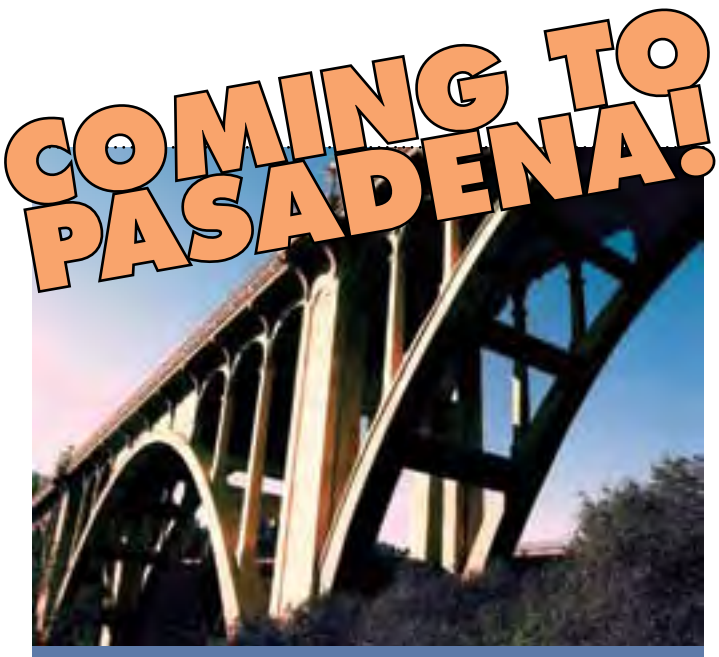
The Planetary Society has been supporting Fischer's FINDS (Fiberoptic Improved Next-generation Doppler Search) Exo-Earths projects for some time. Using our support, the research team has built and installed a fiber-optic "scrambler" on the 3-meter Lick Observatory telescope in California. The new system has yielded much greater stability and precision in the planet hunting conducted there.

Using what they have learned, the team is in the process of miniaturizing its fiber scrambler system for use on a 10-meter telescope at Keck Observatory in Hawaii. The scientists also have produced several technical publications and presentations based on what they have learned in developing the FINDS system, thus assisting the entire community of planet hunters.

More recently, they have taken what they learned in FINDS development and created a new fiber scrambler, as part of a whole new spectrometer system, on the 1.5-meter telescope at the Cerro Tololo Inter-American Observatory (CITO) in Chile. The throughput of the instrument (percentage of light getting through the system) is one of the highest—if not the highest—of any planet-hunting system. In its Southern hemisphere site, CITO can see Alpha Centauri, which consists of a Sun-like star (Alpha Centauri A); a somewhat smaller, cooler star (Alpha Centauri B); and a much smaller star that is far from the other two (Proxima Centauri). Both A and B are very bright, thanks to their inherent brightness and particularly due to their "closeness" to us of about four light-years. What that means is that you can use a smaller telescope, like the one at CITO, to look for planets as long as you have the right back-end equipment. Utilizing a "small" telescope, viewing time is cheaper (and you can get a lot more of it) than on a big telescope, conditions that are great for planet hunting, which is best done with lots of observations.

Stay tuned for what Debra, Julien, and their colleagues find. In the meantime, learn more about planet hunting and the FINDS project on our website (PLANETARY.ORG), which includes a recent *Planetary Radio* interview with Debra Fischer.

Thanks! Planetary Society Members have helped make the FINDS Exo-Earths project possible.



Planetfest2012
Curiosity Knows No Bounds

August 4–5, 2012, Pasadena Convention Center, CA, USA

Share the excitement!
Make plans to party with The Planetary Society and space enthusiasts around the world this summer as we celebrate the landing of *Curiosity*, the Mars Science Laboratory, on the Red Planet!

Be there...

Experience *Curiosity*'s landing in real time with expert commentators:

- Bill Nye the Science Guy®
- Charles Elachi
- Jim Bell
- Robert Picardo
- Scott Maxwell
- Jim Green
- Alan Stern
- Chris Carberry
- Robert Zubrin
- ... and more

Enjoy...

- *Planetary Radio Live*
- A Space Art Show
- Activities for the Whole Family
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Details:

- August 4, 9:00 a.m. to 5:00 p.m.
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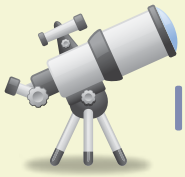
Pasadena Convention Center
300 E. Green Street, Pasadena, CA 91101

For more info, keep an eye on ***planetary.org***.

WHAT'S UP? *by Bruce Betts*



IN THE SKY

Venus transits the Sun on June 5 or 6, depending on time zone. This will not occur again until the year 2117! Be careful when observing: use proper solar filters, or project an image of the Sun onto a surface. The transit will be best viewed from the Pacific Ocean. Observers in North America will be able to see the start of the transit before sunset, while those in southern Asia, northern Africa, and most of Europe will see the end of it. There is an annular solar eclipse (the Moon is centered in front of the Sun but does not cover it entirely) on May 20. Its path goes from China to Japan, across the Pacific, and into the western United States. A partial solar eclipse will be visible over a much broader area from eastern Asia, across the Pacific, and throughout most of North America. A partial lunar eclipse will occur June 3 and 4 and will be visible from most of Asia, Australia, the Pacific Ocean, and the Americas.

RANDOM SPACE FACT

Transits of Venus were used to estimate the distance from the Earth to the Sun, starting with the transit in 1639. Great improvements were made in 1761 and 1769 and again in 1874 and 1882 (Venus transits occur in pairs eight years apart).

TRIVIA CONTEST

Our Winter Solstice 2011 contest winner is Neil McBride of Salt Lake City. Congratulations! **THE QUESTION WAS**: Mars' atmosphere is 95 percent carbon dioxide. What is the second most common gas in the Martian atmosphere? **THE ANSWER**: Nitrogen, at a little less than 3 percent of the atmosphere.

Try to win a free year's Planetary Society membership and a *Planetary Radio* T-shirt by answering this question:

Relative to the Sun, what was the fastest spacecraft ever?

E-mail your answer to *planetaryreport@planetary.org* or mail your answer to *The Planetary Report*, 85 South Grand Avenue, Pasadena, CA 91105. Make sure you include the answer and your name, mailing address, and e-mail address (if you have one). Submissions must be received by June 1, 2012. The winner will be chosen by a random drawing from among all the correct entries received.

For a weekly dose of "What's Up?" complete with humor, a weekly trivia contest, and a range of significant space and science fiction guests, listen to *Planetary Radio* at *planetary.org/radio*.

SPOTLIGHT ON:

Transit of Venus

June 2012

Bill Nye invites you to
"Consider a trip with The Planetary Society. We'll take you to remarkable places!"

Join us for the transit of Venus on June 6, 2012. Experience Siberia and Lake Baikal, or journey to one of the greatest places on Earth: Hawaii. The transit of Venus is extremely rare; the previous one occurred in 2004. The nature of the motion of Venus means that these transits occur in pairs, and the next one is almost upon us. After that, there will be no others until 2117, so the June 6 transit of Venus is a last-in-a-lifetime opportunity!

See the Transit of Venus from **SIBERIA & LAKE BAIKAL**
June 1-12, 2012

Or view it from
DISCOVER HAWAII
June 4-12, 2012

You can also come with us on a journey to Australia this November to see the total solar eclipse from Cairns.

AUSTRALIA Total Solar Eclipse
November 5-16, 2012
With Optional NEW GUINEA Extension November 15-20

Join us on one of these great adventures!

Betchart Expeditions
17050 Montebello Road
Cupertino, CA 95014-5435
Tel: (800) 252-4910 or (408) 252-4910
Fax: (408) 252-1444
E-mail: *info@betchartexpeditions.com*

HERE ARE JUST A FEW of the amazing things our Regional Volunteer Coordinators have done over the last year:

In Venezuela, **PATRICK MORTON** of Maracaibo continued to run the Los Robles Astronomy Club for local students and others who are interested in learning about astronomy, giving them a chance to develop and explore a lifelong passion for space.

KEVIN NOLAN of Dublin, Ireland created and delivered a series of lectures called "Mars Science Laboratory: In Search of Origins." You can find out more about his inspiring talks at *http://www.planetary.ie/*.

MIGUEL GONCALVES in Lisbon, Portugal, representing The Planetary Society, does a brief science show for a Portuguese public TV station every week. You can see him here: *http://www.rtp.pt/multimediahtml/video/bom-dia-portugal/2011-12-10/3parte*.

Sarasota, Florida's **KAREN SULPRIZIO** spoke on behalf of the Society for Carl Sagan Day, giving an inspiring presentation about the history and mission of the Society and what we're doing now to advocate for space science.

PATRICIA MILNER organized screenings of Carl Sagan's original *Cosmos* series in Southern California. The events involved guest speakers on topics related to the episode and a social hour in which attendees could meet the guest speaker and mingle with one another.

Our new mission this year as a Global Volunteer Network is to coordinate events internationally so we give our Members all over the world a chance to participate in fun activities and so we can all share our passion for astronomy and space exploration. If you are interested in learning more about our Global Volunteer Network or coordinating an event, contact Global Volunteer Coordinator Tom Kemp at *tom.kemp@planetary.org*.

–Danielle Hannah,
Global Regional Coordinator

I took this sunset photo on September 12, 2009 using a 5-megapixel Kodak Z730 digital camera from the balcony of our stateroom aboard a cruise ship. We had just exited Vancouver harbor and were sailing due west through Burrard Inlet into the Strait of Georgia, en route to Alaska and eventually Beijing. Vancouver Island is in the background. It was one of the most intensely beautiful sunsets my wife and I had ever seen. And true to form ("red sky at night, sailor's delight"), we had picture-perfect weather the whole way to Anchorage. It was an auspicious portent for what was to be a most memorable 25th-anniversary cruise. I joined The Planetary Society soon after it was formed and am one of its earliest members. I became fascinated with space travel and exploration at a young age in the 1950s. My science project in ninth grade was a scale model of the *Sputnik* satellite. I vividly remember watching the live TV broadcast of Neil Armstrong walking on the moon when I was in college. *—Ken Barker, Allison Park, Pennsylvania*

Planetary Society members are united in their love of space exploration—which has its origins in Earth's skies. Thank you for sharing your views with us! To see more, go to MYSKY.PLANETARY.ORG.

When gazing at the night sky, one cannot fail to be mesmerized by its beauty. It has held us spellbound since the earliest human looked upon it and wondered, "What is out there?" It has resulted in our endeavor to venture out there and to search for an answer to the question "What is our place in this grand scheme of things?" But when we look to the skies, sometimes we forget the beauty right here on planet Earth. That is why I have decided to submit a photo of one of the marvels of our own Earth—the Grand Canyon—to MySky. This was taken last December on a flight en route to Los Angeles. One day, the astronauts who will visit Mars may get a similar glimpse of Valles Marineris.
—Suranga Ruhunusiri, Iowa City, Iowa

WANT TO SHARE YOUR SPACE IMAGE? Send us an e-mail with a jpeg (less than 5 MB) attachment of your image to *planetaryreport@planetary.org*. Please use the subject line "MySky" and include a short caption (such as where you took the image and, if appropriate, with what equipment) and credit line for the image. Please include just one MySky image per submission. Also, be sure to include your name, contact information, and membership number (it's on your membership card and on the mailing label of your magazine). We'd also love to receive a picture of you and to learn more about what is most important to you about being a Planetary Society Member. Questions? E-mail *planetaryreport@planetary.org* or call (626) 793-5100, extension 218.

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Wow, do you ever make a difference!

Take a look at the image on this page, of a robotic probe tantalizingly close to the icy dwarf planet Pluto, with its moon Charon in the distance.

Take a look at the phrases: "*New Horizons*." "First Spacecraft to Explore Pluto." "2015."

Wow. As a Planetary Society Member, I take great delight in that image and in those words. I hope that you do as well.

Why? Because they celebrate a mission that you and I—Planetary Society Members—made possible. In 2015, *New Horizons* will reach never-before-explored Pluto, thanks to you.

Planetary Society Members were tireless in our efforts to get a mission to Pluto, from the beginning of our rally in 2001 until the mission successfully launched in 2006. *Planetary Society Members make a difference.*

Perhaps, as shown in this design concept, we'll also have a postage stamp in honor of this mission, to recognize what we Members helped to achieve. The *New Horizons* team members, along with thousands of people worldwide, have petitioned the United States Postal Service to commemorate the historic flyby of Pluto.

Space artist and Southwest Research Institute scientist Dan Durda created the spectacular artwork for the stamp. Dan is also an adviser to the Society's **GENE SHOEMAKER NEAR-EARTH OBJECTS GRANTS** program. That's another project that makes an impact, helping to protect our pale blue dot of a planet thanks to the generous support of you and your fellow Planetary Society Members.

Today, your voice is needed. You and I—Planetary Society Members—have the power to shape our future in space; to demand, as you did for Pluto, the exploration of worlds beyond our own.

You can learn more and donate at *planetary.org*.

You make a difference. Thank you.

–Andrea Carroll, Director of Development